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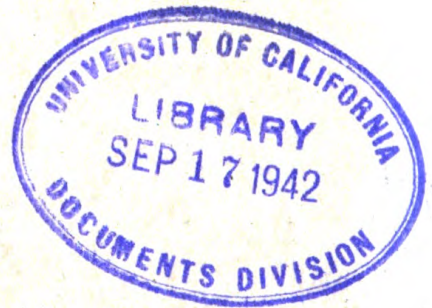
WAR DEPARTMENT

U.S. Dept. of Army

TECHNICAL MANUAL

TEST SETS EE-65 AND EE-65-A

August 25, 1941



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★ ★ TECHNICAL MANUAL

TEST SETS EE-65 AND EE-65-A

CHANGES }
No. 1 }

WAR DEPARTMENT,
WASHINGTON, February 14, 1942.

TM 11-361, August 25, 1941, is changed as follows:

2. Set box.

* * * * *

b. Test sets EE-65-A and EE-65-B.—Test sets **EE-65-A** and **EE-65-B** are identical in their electrical characteristics. A larger voltmeter may be used in test set **EE-65-B**, thus necessitating a slightly deeper cover. Otherwise test sets **EE-65-A** and **EE-65-B** are identical. The set box consists of a wooden or fiber case otherwise similar to that for **EE-65**, except that instead of a compartment for listening equipment a small receptacle is installed in the cover for storage of the three test clips. A diagram of the wiring of the test set is also inside the cover. No ground rod is furnished.

[A. G. 062.11 (12-16-41).] (C 1, Feb. 14, 1942.)

24. Wire and cable resistance and weight.—Resistances and weights of wires * * * and less for a lower temperature.)

	Weight per mile	Resistance per mile of single conductor
	Pounds *	Ohms *
Cable, paper-insulated, lead-covered:		
No. 19 A. W. G., 10 pair (cable WC-401)-----	4, 224	43
No. 22 A. W. G., 10 pair (cable WC-411)-----	2, 798	86
Cable, rubber-insulated, rubber-covered:		
No. 19 A. W. G., 5 pair (cable WC-534)-----	660	43
No. 19 A. W. G., 10 pair (cable WC-535)-----	1, 320	43

[A. G. 062.11 (12-16-41).] (C 1, Feb. 14, 1942.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

E. S. ADAMS,
*Major General,
The Adjutant General.*

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TECHNICAL MANUAL }
No. 11-361

WAR DEPARTMENT,
WASHINGTON, August 25, 1941.

TEST SETS EE-65 AND EE-65-A

Prepared under direction of the
Chief Signal Officer

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*This manual supersedes TR 1265-10, June 16, 1931.

SECTION I

DESCRIPTION

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1. Purpose.—These sets have been designed to provide a wire chief's testing equipment in a compact portable form for use in the field and in permanent central office installations. In test set EE-65, complete testing, signaling, and talking equipment is installed in a substantial case, which is provided with a shoulder strap and can easily be transported by one man. No additional equipment is necessary for its operation. Test set EE-65-A is equally portable and complete except that a telephone handset must be connected externally to a jack or binding posts provided for that purpose.

2. Set box.—*a. Test set EE-65.*—The set box consists of a fiber covered wooden case, metal bound, with hinged cover; it is provided with a quick-acting latch lock and has two metal fittings for attaching the carrying strap. The case acts as a support for the testing equipment, the entire set of keys, voltmeter, generator, buzzer, and induction coil, together with the necessary wiring, being mounted on a hinged insulating panel. Within the case is a compartment for the talking and testing batteries, while a compartment on the left side of the test panel provides space for carrying the transmitter and receiver, test cords, and clips. Inside the cover is a clip for holding the ground rod.

b. Test set EE-65-A.—The set box consists of a wooden or fiber case otherwise similar to that for EE-65, except that instead of a compartment for listening equipment a small receptacle is installed in the cover for storage of the three test clips. A diagram of the wiring of the test set is also inside the cover. No ground rod is furnished.

3. Test unit.—*a. Test set EE-65.*—(1) The test unit set up in position for service is shown in figure 1. The voltmeter at full scale reads 50 volts. Each space on the scale has the value of 1 volt, every fifth and tenth unit being marked by a longer line on the scale. The upper left-hand binding post is for the ground connection and is designated GND. The next two posts are the line terminals and are designated L-1 and L-2, respectively. The thumbscrew directly over the voltmeter locks the front panel in position. At the upper right-hand side are two binding posts for connecting any external source of electromotive force whose value is to be measured. These posts are designated BAT TEST, the left-hand one being the positive post.

(2) The transmitter is connected to the two upper binding posts located at the lower left-hand side of the testing panel and is designated TRANS. The testing receiver is connected to the next two binding posts which are designated REC. Two-way flexible cords are used for these connections, and in addition there is a supporting strand to take the strain from the terminals. The generator handle is located in the lower center of the panel. The two binding posts at the lower right-hand side of the panel provide terminals for an external battery, the upper one of the pair being the positive terminal. When an external battery is used, the battery within the case must be disconnected.

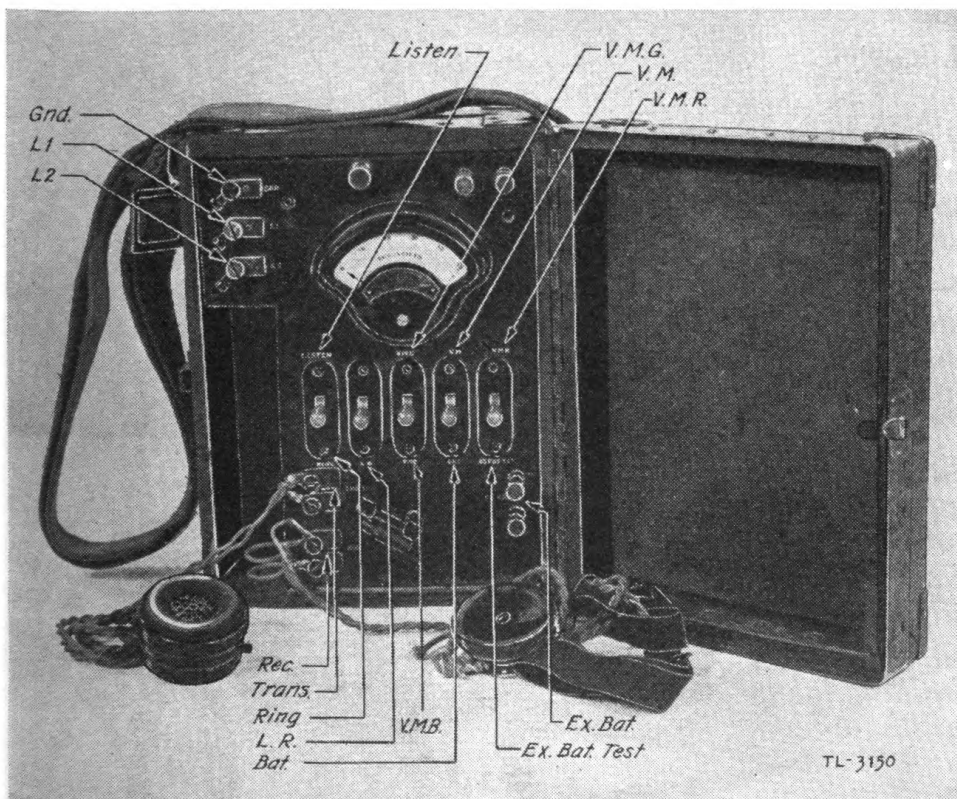


FIGURE 1.—Test set EE-65 ready for operation (front view).

b. Test set EE-65-A.—(1) The test unit set up in position for service is shown in figure 2. The voltmeter at full scale reads 50 volts. Each space on the scale has the value of 1 volt, every fifth and tenth unit being marked by a longer line on the scale. The upper left-hand binding post is for the ground connection and is designated GND. The next two posts are the line terminals and are designated L-1 and L-2, respectively. The thumbscrew directly over the volt-

meter locks the front panel in position. At the upper right-hand side are two pairs of binding posts. The upper pair is for connecting any external source of electromotive force whose value is to be measured. These posts are designated BAT TEST, the upper one being

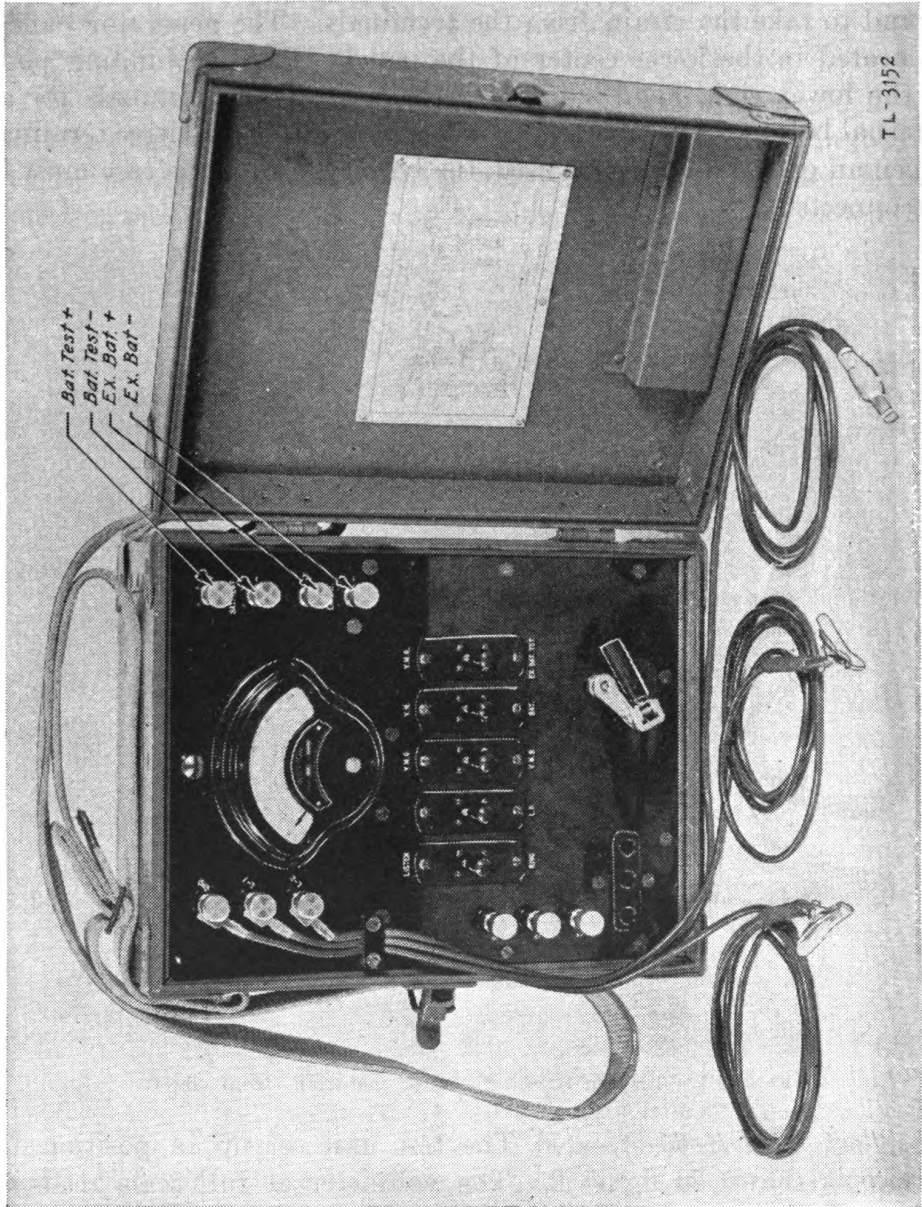


FIGURE 2.—Test set EE-65-A ready for operation (front view).

the positive terminal. The lower pair of binding posts provides a means of connecting an external battery. When an external battery is used, the battery within the case must be disconnected.

(2) The handset, if similar to the TS-9, is connected to the jack JK-37 at the lower left-hand side; otherwise the handset is connected to the binding posts at the lower left-hand side. The posts are designated T, C, and R. The generator handle is located in the lower center portion of the panel.

4. Test keys and their uses.—The various talking and testing circuits of the set are controlled by five keys mounted in a row in the center of the testing panel. For purposes of identification, keys are considered as numbered from left to right.

a. Key No. 1 when thrown up (locking position) is used for listening or talking. When pulled downward (nonlocking position) it is used for ringing out on the test leads, the generator crank being turned at the same time. The buzzer provides a signal to show whether or not the line is closed. Key No. 1 on test set EE-65-A locks in both the up and down positions.

b. Key No. 2 can be moved only to the downward position and is used for reversing the test leads.

c. Key No. 3 when in the "Up" position connects the positive side of the test battery to GND and connects the negative side of the battery through the voltmeter to L-1, or to L-2 if key No. 2 is also operated. Key No. 3 is used when testing for grounds. When thrown to the "Down" position, the voltmeter, in series with the testing battery, is connected directly across L-1 and L-2 for locating short circuits or making other resistance tests.

d. Key No. 4 in the "Up" position disconnects the testing battery and is always used in conjunction with key No. 3. If used with key No. 3 thrown up, it connects the voltmeter directly across L-1 and GND. With key No. 3 down, it connects the voltmeter directly across L-1 and L-2. Throwing key No. 4 down connects the voltmeter across the self-contained testing battery.

e. Key No. 5 in the "Up" position is used to reverse the terminals of the voltmeter. This relieves the tester from having to change the test leads when measuring external battery. In the "Down" position the voltmeter is connected directly across the BAT TEST posts for measuring any outside potential within the range of the voltmeter. Various combinations of the keys provide the necessary testing circuits for the usual magneto or common battery system tests.

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EMPLOYMENT

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Test for crosses with other lines.....	16
Measuring external battery voltage.....	17
Ring tests for open circuits, short circuits, or grounds.....	18
To determine value of unknown resistance.....	19
To determine capacitance between two wires.....	20
Line out of order.....	21

5. Tests.—*a.* These test sets, as previously stated, have been designed to provide a means of making the usual tests for local battery or common battery requirements. In general, the test set can be used either in a vertical or a horizontal position. If the voltmeter fails to read “zero” with all keys normal, adjust the screw on the face of the voltmeter.

b. The resistance of the voltmeter in test set EE-65 is approximately 3,000 ohms.

c. The resistance of the voltmeter in test set EE-65-A is approximately 50,000 ohms. This resistance of 1,000 ohms per volt makes it convenient for performing insulation resistance measurements.

6. To ring local battery substation or exchange.—*a. Test set EE-65.*—Hold key No. 1 down and at the same time turn the generator crank. Party line ringing signals can be made by moving the key from “Normal” to “Down” the required number of times. To signal or ring on a ground return circuit, L-1 clip should be connected to the desired line wire and L-2 clip grounded. Conditions will then be similar to ringing on a metallic circuit.

b. Test set EE-65-A.—This set operates in a manner similar to *a* above, except that key No. 1 locks in the down position. All operations are otherwise the same. By virtue of the fact that this key locks in the down (RING) position, the test set can be left on the line with key No. 1 operated and receive an incoming signal.

TECHNICAL MANUAL

TEST SETS EE-65 AND EE-65-A THROUGH -G

CHANGES
No. 3

WAR DEPARTMENT,
WASHINGTON 25, D. C., 28 July 1944.

TM 11-361, 2 February 1943, is changed as follows:

Title of manual is changed to read: TEST SETS EE-65 AND EE-65-A THROUGH -G.

1. **Purpose.**—Test sets EE-65 and EE-65-A, -B, -C, -D, -E, -F, and -G have been designed to provide a wire chief's testing equipment in a compact portable form for use both in the field and in permanent central office installations.

2. **Description.**

b. (As changed by C 2.) There are minor * * * their key connections. The test set EE-65-G is identical with test sets EE-65-C, -D, -E, and -F, except for the following minor differences:

- (1) The chassis is steel instead of aluminum.
- (2) Generator GN-38-B is used in place of generator GN-38. In an emergency, generator GN-38 can be used for replacement.
- (3) Minor changes regarding lay-out of mounting holes and fastening to hinge have been made on the panel.
- (4) The key mounting bars are steel and are mounted differently.
- (5) The hinge studs and supports are steel. The supports are shorter.
- (6) All screws are now finished steel.
- (7) Minor changes regarding construction details, location of rivets, and hardware have been made.
- (8) The circuit plate contains a schematic wiring diagram and parts list with nomenclature.

d. (As changed by C 2.) Hereafter when the information contained herein applies to all models of this test set, they will be referred

*This change supersedes C 1, 30 March 1943; and TB 11-361-1, 26 April 1944.

to collectively as test set EE-65-(*); and when reference is made to test sets EE-65-C, -D, and -E, such references apply also to test sets EE-65-F and -G, except when otherwise noted.

10. To signal a common battery exchange.

b. Test sets EE-65-A and -B.—The 0.5 μ f capacitor of auxiliary equipment. To signal and talk to a common battery exchange, coil C-158 or suitable substitute is needed. To signal the release the line.

26. Functioning of parts.—The following is in test set EE-65-(*).

a. Generators GN-38 and GN-38-B.—Generator GN-38 is used in test sets EE-65-A through -F. Test set EE-65-G uses generator GN-38-B. Either generator may be used in test sets EE-65-A through -G. Generator GN-38 has three small cobalt-steel permanent magnets arranged on two-pole faces about an armature. Generator GN-38-B has two stationary magnets and two pole pieces arranged alternately around an armature. Otherwise, the generators are similar. When cranked at with the buzzer.

b. A-c buzzer.—This is a milliamperes ringing current.

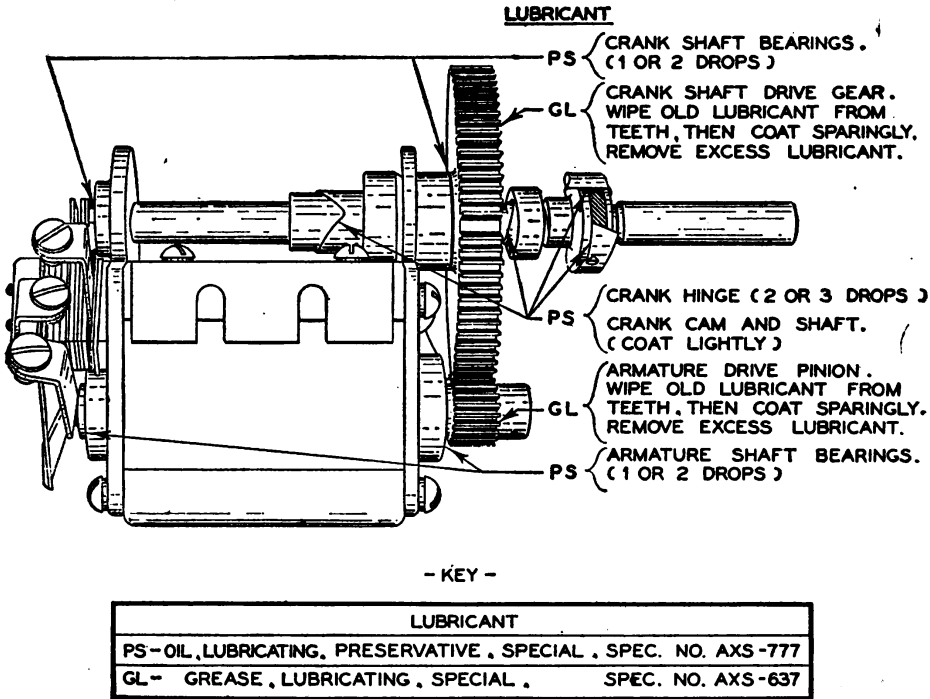
Note.—The buzzer BZ-4 is used only with test set EE-65 and is not interchangeable with the 80-ohm, a-c buzzer (item 14 on SC-D-9609-C), used in test sets EE-65-A through -G.

31. Removal and assembly of parts.

d. To remove generators GN-38 or GN-38-B.—Disconnect wires and of the chassis.

31.1. (Added.) Lubrication of generators GN-38 and GN-38-B.—The only parts of test sets EE-65-A through -G which require lubrication are the moving parts of generators GN-38 and GN-38-B. Lubrication must be performed every 512 operating hours. Use either oil (lubricating, preservative, special), or grease (lubricating, special) as directed in figure 24. The lubricants recommended can be used at all temperatures. Before lubricating parts with oil (lubricating, preservative, special), wipe dust from exposed surfaces. Lubricate sparingly to prevent lubricant from entering generator case or

getting on electrical contacts. Use only solvent, dry cleaning for cleaning generator.



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FIGURE 24.—Lubricants and lubrication points for generators GN-38 and GN-38-B.

31.2 (Added.) Moistureproofing and fungiproofing.—a. General.—Communication failures commonly occur when Signal Corps equipment is operated in tropical areas where temperature and relative humidity are extremely high. The following problems are typical:

- (1) Resistors and capacitors fail.
- (2) Electrolytic action takes place in coils, causing eventual break-down.
- (3) Hook-up wire and cable insulation break-down. Fungus growth accelerates deterioration.
- (4) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs and crosstalk.
- (5) Moisture provides leakage paths between battery terminals.

b. Treatment.—A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray,

TM 11-361

C 3 TEST SETS EE-65 AND EE-65-A THROUGH -G

and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied by a spray gun and/or a brush.

c. Step-by-step instructions. — (1) *Preliminary instructions.* — (a) Make all repairs and adjustments necessary for the proper operation of the equipment.

(b) Thoroughly clean all dirt, dust, fungus, oil, grease, etc., from the equipment.

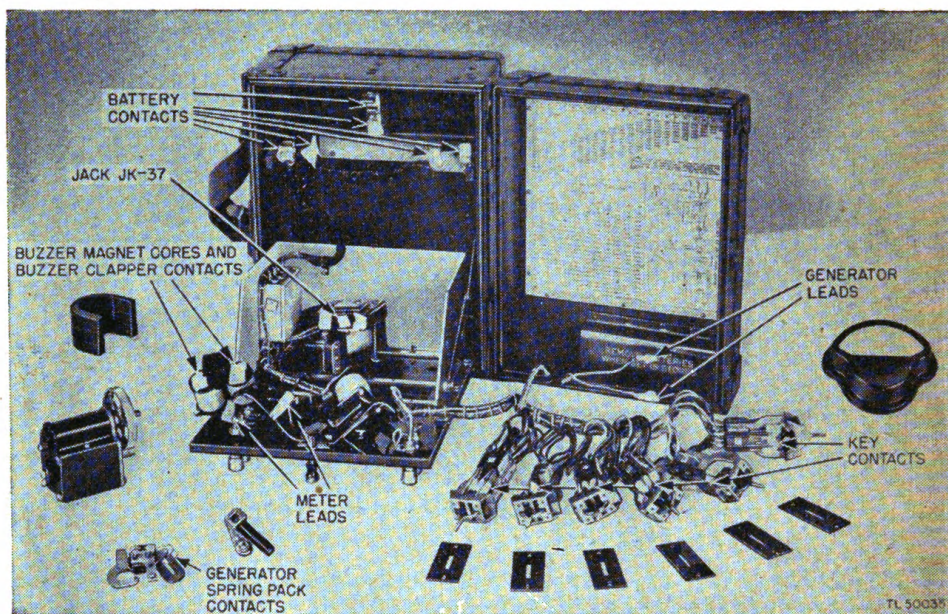


FIGURE 25.—Test set EE-65-F, disassembled and masked.

- (2) *Disassembly.* (a) Remove fiber clamp over three test leads.
- (b) Remove test leads (not to be treated).
- (c) Loosen knurled nut above meter to open case.
- (d) Remove generator handle.
- (e) Screw down knurled binding posts.
- (f) Remove key handles (not to be treated).
- (g) Remove keys. Do not unsolder the leads.
- (h) Remove generator.
- (i) Remove spring pack from generator.
- (j) Remove buzzer. Do not unsolder the leads.
- (k) Remove meter.
- (l) Remove induction coil C-105 and holding coil C-158 from cabinet. Do not unsolder leads.
- (m) Remove jack JK-37. Do not unsolder the leads.
- (n) Remove batteries.

(3) *Masking*.—Cover the following parts with masking tape (fig. 25):

- (a) Two magnet cores on buzzer.
- (b) Two contacts on buzzer clapper.
- (c) All key contacts.
- (d) Three plug holes on jack JK-37.
- (e) All battery contacts.
- (f) All contact points on generator spring pack.
- (g) Terminals of the leads to the meter.
- (h) Terminals of the leads to the generator.

(4) *Drying*.—Place all equipment except batteries, test leads, and key handles in an oven and dry for 2 or 3 hours at 160° F.

Caution: Do not apply heat to batteries.

(5) *Varnishing*.—Apply three coats of moistureproofing and fungi-proofing varnish.

- (a) Do not spray generator or meter. Varnish with a brush.
- (b) Using a full brush, varnish the meter as follows:

- 1. Seal all holes in the case.
- 2. Seal the joint between the back plate and the case shell.
- 3. Varnish the screws holding the back plate to the case.
- 4. Varnish the edge of the meter glass.
- 5. Varnish the zero set adjustment screw.

(6) *Cleaning contacts*.—Remove all masking tape. Clean all contacts with varnish remover and burnish the contacts.

(7) *Reassembly*.—Reassemble the set, and test operation.

(8) *Marking*.—Mark MFP and date of treatment (example: MFP-4 April 1944).

d. Reference.—For a full description of the varnish spray method of moistureproofing and fungiproofing refer to TB SIG 13.

33. List of replaceable parts.—*a. Components*.—The following components are supplied as parts of test sets EE-65-C, -D, -E, -F, and -G.

	Dimensions	Weight (lb.)	(oz.)
* * * * *		*	*
Chassis, on which are mounted—			
1 generator GN-38 with crank GC-9	-----	2	2
or			
1 generator GN-38-B with crank GC-9 (supplied with test set EE-65-G only)	-----	2	--
1 capacitor CA-355	-----	--	5

The following parts * * * chest set TD-1.

b. (Superseded.) *List of maintenance parts.*—Test sets EE-65-A through -G.**Note:** Order maintenance parts by stock number, name, and description.

Ref. symbol	Signal Corps stock No.	Name of part and description	Organizational stocks	3d ech.	4th ech.	5th ech.	Depot stocks	Quantity per unit
	3E1478	CORD CD-38: test lead	-----	*	*	*	*	3
	4B838	GENERATOR GN-38	-----	*	*	*	*	1
	4C9895/1	HANDLE: key lever; black	-----	*	*	*	*	5
	4C4020	HANDLE: key lever; red	-----	*	*	*	*	1
	3F293	VOLTMETER IF-93: d-c; 0-50 volts; Marion Electric Instrument Company; Model MC1M.	-----	*	*	*	*	1
		GENERATOR GN-38 REPAIR PARTS						
	4B838/A5	ARMATURE ASSEMBLY	-----	*	*	*	*	1
	4B838/S1	CRANKSHAFT AND CAM ASSEMBLY: shaft with driving cam and buffer.	-----	*	*	*	*	1
	4B838/G1	GEAR: large; 99 tooth	-----	*	*	*	*	1
	4B838/G2	GEAR: pinion; 21 tooth	-----	*	*	*	*	1
	4B838/P1	PIN: for pinion gear	-----	*	*	*	*	1
	4B838/S3	SPRING: steel wire; cam operating	-----	*	*	*	*	1
	4B838/S2	SPRING: assembly; contact	-----	*	*	*	*	1
	6L6632-8.5	SCREW: machine; No. 6-32 x 1/2" round head; generator contact spring assembly mounting.	-----	*	*	*	*	1
	6L6832-6.5A	SCREW: machine; No. 8-32 x 3/8"; round head; generator assembly.	-----	*	*	*	*	1
	6L6832-6.7A	SCREW: machine; No. 8-32 x 1/2"; flathead; generator assembly.	-----	*	*	*	*	1
	6L6832-2.31S	SCREW: set; No. 8-32 x 1/8"; cup point; headless; steel; crankshaft collar locking.	-----	*	*	*	*	1
	6L73006	WASHER: lock; steel; for No. 6 screw; generator assembly	-----	*	*	*	*	1
	6L73008	WASHER: lock; steel; for No. 8 screw; generator assembly	-----	*	*	*	*	1

35. Manufacturers and their addresses (Rescinded).

[A. G. 300.7 (19 Jul 44).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:

As prescribed in paragraph 9a, FM 21-6; B 1, 2, 4, 6, 17 (2);
R 1, 2, 4, 5, 6, 17 (3); Bn 11 (2); IBn 1, 5 (5); IC 4, 5, 44 (3);
IC 11 (5).

IBn 1: T/O 1-27, 1-67, 1-117, 1-127, 1-137, 1-317, 1-487S,
1-637, 1-758, 1-767, 1-777S, 1-999.

IBn 5: T/O 5-515S.

IC 4: T/O 4-46.

IC 5: T/O 5-512S.

IC 11: T/O 11-97, 11-107, 11-27, 11-18, 11-7, 11-217, 11-227,
11-237, 11-247, 11-257, 11-287.

For explanation of symbols, see FM 21-6.

7. To signal common battery exchange.—*a. Test set EE-65.*—Move key No. 1 up. This places the receiver and the induction coil in series across the line and provides the necessary shunt to operate the central office signal.

b. Test set EE-65-A.—The 0.5 μ f. capacitor in series with the telephone circuit of this test set prevents its use with a common battery switchboard without the use of auxiliary equipment. To signal and talk to a common battery exchange, a coil 12-A or 12-S or suitable substitute is needed. To signal the exchange connect the coil across the terminals L-1 and L-2. This will provide the necessary shunt to operate the central office signal and present a high impedance to the voice currents. The coil must be disconnected when it is desired to release the line.

8. To talk to local battery substation or exchange or to common battery exchange.—Move key No. 1 up and press the small button on the transmitter or handset which supplies the 3-volt battery to the transmitter. In order to conserve the battery, press the button only while actually talking.

9. To talk to common battery substation.—While these sets are not wired to supply talking battery to a common battery substation, it is possible to do so by making the following connections: With key No. 1 up, connect the two terminals marked EX BAT to the L-1 and L-2 terminals in series with an externally connected 165-ohm retardation coil. Connect L-1 and L-2 to the desired line by means of the test clips. This method should be used only in an emergency as the drain on the test battery is excessive.

10. Test for continuity of metallic circuit.—Move key No. 3 down. The voltmeter is then connected in series with the testing battery, the combination being connected directly across the test leads L-1 and L-2. The voltmeter reading, as compared with the reading on short circuit, will be a measure of the resistance of the external circuit. The greater the reading of the voltmeter when connected to the external circuit, the smaller will be the value of the resistance being measured. Voltmeter readings and the equivalent resistances in ohms are given in paragraph 25. An open line will not show any permanent deflection of the voltmeter needle.

11. Test for continuity of ground return circuit.—Move key No. 3 up. Connect the ground post GND to a water pipe or, if using the set in the field, ground in moist earth. Connect the line to the L-1 binding post. If the line is closed the voltmeter will give a reading as explained in paragraph 10.

12. Test for ground on metallic circuit.—Move key No. 3 up. Connect L-1 and L-2 to the desired circuit. Connect the GND post

to ground. If the voltmeter shows a reading the wire connected to L-1 is grounded. Next operate key No. 2 down. If no voltmeter reading shows, the L-2 wire, which has been substituted for the L-1 wire by the operation of key No. 2, is clear. Cases may develop where both sides of the line are grounded or where the line is short-circuited and one side grounded. In either case the voltmeter will show a reading both when key No. 3 is thrown upward and when it is thrown downward. In the case where there are a short circuit and a ground on one side, to make a partial test for the location of the ground—

a. Operate key No. 3 up and read the voltmeter.

b. Keeping key No. 3 up, operate key No. 2 down and read the voltmeter.

The wire giving the greater reading will probably be the grounded wire.

13. Test for capacitance.—(Such as a substation with a capacitor in its bell circuit.) Move key No. 3 down. Move key No. 2 to "Down" and back to "Normal". The needle will deflect and return to zero. Read the scale at the maximum point of this deflection or "throw". The set can be calibrated by reading the "throw" on lines having one bell and one capacitor, two bells and two capacitors, etc. The capacitor at the station is first charged by the operation of key No. 3 and then discharged and charged in the opposite polarity by the operation of key No. 2.

14. Test for open circuit.—*a. One conductor of pair open.*—Move key No. 3 up. Connect the line wires to L-1 and L-2 and connect GND to ground. Move key No. 4 up and back to the normal position and read the voltmeter "throw". The voltmeter "throw" is proportional to the capacitance between the wire connected to L-1 and the earth. (See also par. 13.) Operate key No. 2 and repeat the process. This time the voltmeter "throw" is proportional to the capacitance between the wire connected to L-2 and the earth. The distance to the point at which the circuit is open can be found approximately by a comparison of these two readings.

L = known length of good conductor.

L' = distance to open circuit in faulty conductor.

L = voltmeter "throw" for good conductor.

V' = voltmeter "throw" for open-circuited conductor.

$$\frac{L}{L'} = \frac{V}{V'}$$

$$L' = \frac{LV'}{V}$$

b. Both conductors of pair open or metallic conductor of ground return circuit open.—A separate known good conductor paralleling those under test must be used. Connect the good conductor and an open conductor to L-1 and L-2 and follow the same procedure as in *a* above. In this test, it is assumed that any equipment at the distant end has been disconnected and that neither line wire is grounded.

15. Test for crosses with lines carrying current.—Move key No. 3 up. Connect GND to ground. Operate key No. 4 up. If the foreign line is one which has its battery grounded, such as a common battery telephone line or a telegraph line, the voltmeter will show a reading. The value of this reading will help to determine the type of circuit that has caused the trouble. If the voltmeter needle tends to move off scale in the direction of zero, move key No. 5 up to reverse the voltmeter. In making these measurements some knowledge of the potentials that may be present on the line is necessary, as the voltmeter may be injured or destroyed by connecting it to lines carrying high voltage. It should be remembered that many telegraph circuits have an applied voltage in excess of 100 volts. If the needle goes off the scale, the tester should immediately restore key No. 3 to normal position to open the voltmeter circuit.

16. Test for crosses with other lines.—In addition to tests outlined in paragraph 15, it may be that two lines, *a* and *b*, are crossed. In this case L-1 is connected to one side of line *a*, and L-2 to each side of line *b* in turn; key No. 3 down, being used. If no reading shows, change L-1 to the other wire of line *a* and repeat the test. A reading of the voltmeter shows that there is a cross. A similar test for crosses with grounded lines may be made, either by grounding L-2 or changing key No. 3 to "Up" and using L-1 and ground.

17. Measuring external battery voltage.—Connect the terminal marked BAT TEST to the battery whose voltage is to be measured. Be sure to connect the positive terminal of the battery to the plus post. Key No. 5 (down) connects the voltmeter directly across these posts, and the instrument will indicate potentials within its range. Care should be exercised not to expose the voltmeter to potentials greater than 50 volts.

18. Ringing tests for open circuits, short circuits, or grounds.—This is a rapid means of testing a number of lines and is especially useful when a new system is being installed. To test for an open or a short circuit, connect L-1 and L-2 to the desired line. Move key No. 1 down, rapidly turning the generator handle at the same time. If the line is open, the buzzer will not sound and the generator turns easily. If the line is closed, that is, the substation bell connected to the line, the generator turns readily and the buzzer

sounds. A high-resistance short circuit gives about the same test as a substation. If the generator turns hard, the buzzer sounding also, a short circuit exists on the line under test. The degree of difficulty experienced in turning the generator and the loudness of the buzzer may be taken as an estimate of the value of the resistance of the circuit. To test for grounds, change L-2 to a ground connection and proceed as indicated above. In making these tests it is best to operate the generator at a constant speed so that the buzzer having once been adjusted may function correctly. Too high a speed increases the frequency of the alternating current produced by the generator; it may be sufficiently high to prevent the operation of the buzzer and may thus give an inaccurate test.

19. To determine value of unknown resistance.—*a. Method.*—This method of testing is based on the principle that in any series circuit through which a fixed value of direct current is flowing, the potential across any given resistance is proportional to the value of the resistance. If the resistance of the voltmeter is known, the value of any other resistance in the circuit may be calculated.

Let R = resistance of voltmeter. (Averages 3,000 ohms in test set EE-65, and 50,000 ohms in test set EE-65-A.)

V = reading of voltmeter when test leads are short-circuited. (Key No. 3 down.)

V' = reading of voltmeter when test leads are connected to unknown resistance, that is, voltage across voltmeter. (Key No. 3 down.)

X = value of unknown resistance.

Then $V - V'$ = voltage across resistance.

$$\frac{V'}{V - V'} = \frac{R}{X}$$

or $V'X = (V - V')R$

$$X = \frac{(V - V')R}{V'}$$

b. Examples.—(1) The voltmeter reads 39.5 volts when the test leads are short-circuited. When the test leads are connected to a telephone switchboard drop, the reading of the voltmeter is 32.5 volts. What is the resistance of the drop? Assume the resistance of the voltmeter to be 3,000 ohms. Substituting in *a* above:

$$\frac{(39.5 - 32.5) \times 3,000}{32.5} = \frac{7 \times 3,000}{32.5} = 646 \text{ ohms. Answer.}$$

(2) Suppose it is desired to find the insulation resistance of a certain line. The voltmeter reading on short circuit was 40 volts.

When the set was connected to the line, the voltmeter reading was 12 volts. Assume the resistance of the voltmeter to be 3,000 ohms. Substituting in a above:

$$\frac{(40-12) \times 3,000}{12} = \frac{84,000}{12} = 7,000 \text{ ohms. Answer.}$$

This shows that the smaller the reading of the voltmeter the higher the value of the resistance being measured. As the voltage of the battery falls off with age, frequent checks should be made when making resistance measurements.

20. To determine capacitance between two wires.—This method can be used for roughly determining the location of an open or break in the line. This method was referred to in paragraph 13, a simple method being shown for calibrating the set. To calibrate the set more accurately, proceed as follows:

a. Check the voltage of the test battery by operating key No. 4 to "Down" position. Record this result. Restore key No. 4 to "Normal."

b. Connect a 1- μ f. capacitor (type 21-M, Western Electric Co., or equal) to the testing leads L-1, L-2. Throw key No. 3 to the "Down" position. Move key No. 2 to "Down" and back to "Normal." Read and record the "throw" of the needle.

c. Assume the battery voltage to be 39.5 and the "throw" produced by a 1- μ f. capacitor to be 4.5 volts. A table can then be made as shown below:

$$1 \mu\text{f.} = 4.5 \text{ volts.}$$

$$2 \mu\text{f.} = 9.0 \text{ volts.}$$

$$3 \mu\text{f.} = 13.5 \text{ volts.}$$

$$4 \mu\text{f.} = 18.0 \text{ volts.}$$

d. An application of the test described above can best be understood by a practical problem. An unknown capacitor was tested, the voltmeter "throw" being 2.25 volts. What is its capacity?

Let C = value of standard (1- μ f.).

C' = unknown value.

D = voltmeter reading on standard.

D' = voltmeter reading for unknown capacitor.

$$\text{Then } \frac{C}{C'} = \frac{D}{D'}$$

$$\text{(Substituting) } \frac{1}{C'} = \frac{4.5}{2.25}$$

$$4.5C' = 2.25$$

$$C' = \frac{2.25}{4.50} = 0.5 \mu\text{f.}$$

c. This same principle can be applied to the location of an open circuit in a metallic line. If the distance, in feet or miles, between the two stations is known, the approximate location of the open may be determined. The equipment at the terminal station must be disconnected. Test the circuit for a ground or a short circuit and if it is clear proceed as follows:

Connect the line in question to L-1 and L-2.

Ground the terminal marked GND, and operate the No. 3 key up.

Move key No. 4 up and back to "Normal," reading the "throw" of the voltmeter at the same time. Next, leaving key No. 3 up, throw key No. 2 down and repeat. Read the "throw" of the voltmeter. Then the distance to the fault can be computed.

Let D = voltmeter reading on line wire giving greater "throw."

D' = voltmeter reading on other line wire.

L = distance between stations.

X = distance to fault.

$$\text{Then } \frac{D}{D'} = \frac{L}{X}$$

$$X = \frac{D'L}{D}$$

This test gives an indication of the capacitance between each wire and the earth, but is only an approximate location test.

21. Line out of order.—In testing for an unknown fault, the original report of the trouble in most cases will classify it under one of the headings given above. The most difficult case is the report of the line being "out of order." Assume that such a report has been made on a given telephone line; the procedure would be as follows:

a. Make a voltmeter test to see if the line is closed.

b. Test for grounds.

c. Open the line at the central office protector frame and ring toward the switchboard to see that the drop or signal functions properly.

d. Ring toward substations and try to call a subscriber. After ringing, set the keys for "continuity of a metallic circuit" test (par. 10). Observe the voltmeter and if a deflection is shown after ringing, indicating an answer by the called party, immediately change the keys to the position for "Talk to local battery substation." If no answer is heard when this test is made, wait a few moments, ring the substation again, observe the voltmeter, and if the needle is again deflected the trouble is at the station instrument—the most likely place being in the transmitter circuit. If trouble shows on some of the other tests (*a*, *b*, and *c* above), it is evident that line trouble exists. For efficient test-

ing, a complete record of the cables, lines, and instrument equipment is necessary, and in addition, a general knowledge of outside conditions, foreign wire circuits, pole line lay-outs, etc.

SECTION III

DETAILED FUNCTIONS

Test set circuits-----	Paragraph 22
------------------------	-----------------

22. Test set circuits.—*a.* In figures 5 and 6 are shown the general wiring schemes of test sets EE-65 and EE-65-A, respectively. From the wiring diagrams and a study of figures 1 to 4, inclusive, the actual physical positions of the various items of equipment in the sets and their electrical positions in the various testing circuits can readily be seen.

b. Figure 7 shows the circuits when key No. 1 is in the down or ringing position. To trace the circuits, start at L-1, go through the upper left-hand contact of key No. 1 (key No. 1 being operated), through the automatic switch on the generator shaft, generator, low-resistance buzzer, and through the lower left-hand contact of key No. 1, to the L-2 post. This forms a series circuit, containing the magneto generator and buzzer, connected to the L-1 and L- terminals. For simplicity, only the ringing circuit and adjacent portions of the wiring diagram have been shown in this figure.

c. Figure 8 shows the talking and listening circuits controlled by key No. 1 in the "Up" position. These circuits may be traced in the same manner as indicated in *a* above by following the heavy lines in the figure. The current variations set up by the transmitter in the local circuit produce corresponding voltage variations in the line circuit through the action of the induction coil.

d. In figure 9 the circuit for measuring the potential or voltage of the testing battery is shown. Maintaining key No. 3 at its "Normal" position, operate key No. 4 down. This closes a circuit consisting of the battery and voltmeter in series and the voltmeter reads the battery voltage. If an external testing battery is used, read its voltage by following the same procedure. When an external battery is used, the internal battery must be disconnected; otherwise, unless the batteries have exactly the same voltage, the one with the greater voltage will discharge through the other.

e. The circuit employed in testing the continuity of an external circuit and in determining the value of an external resistance is illustrated in figure 10. The key operation is covered in paragraph 10. This circuit is also used for testing for crosses with other lines as described in paragraph 16.



FIGURE 3.—Interior of test set EE-65.

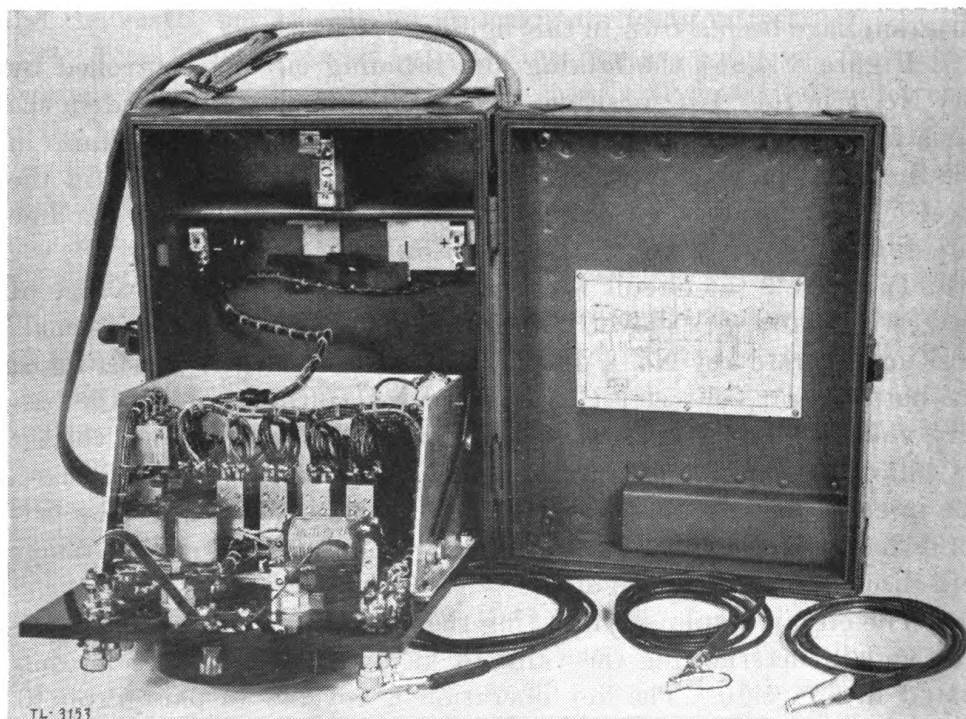
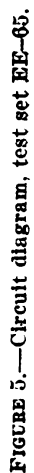


FIGURE 4.—Interior of test set EE-65-A.



TL-3141

f. Figure 11 shows the circuit used in testing for grounds. The key operation is covered in paragraph 12. In this circuit the testing battery and the voltmeter are connected in series across the L-1 and GND terminals.

g. Crosses between a line under test and other lines carrying current are determined by means of the circuit indicated in figure 12, which is the same as the circuit in figure 11 except that key No. 4 has been operated to the "Up" (VM) position. This change cuts off the test battery and closes the voltmeter circuit directly across the L-1 and GND terminals. Therefore, a foreign potential can be measured by the voltmeter. The key operation is covered in paragraph 15.

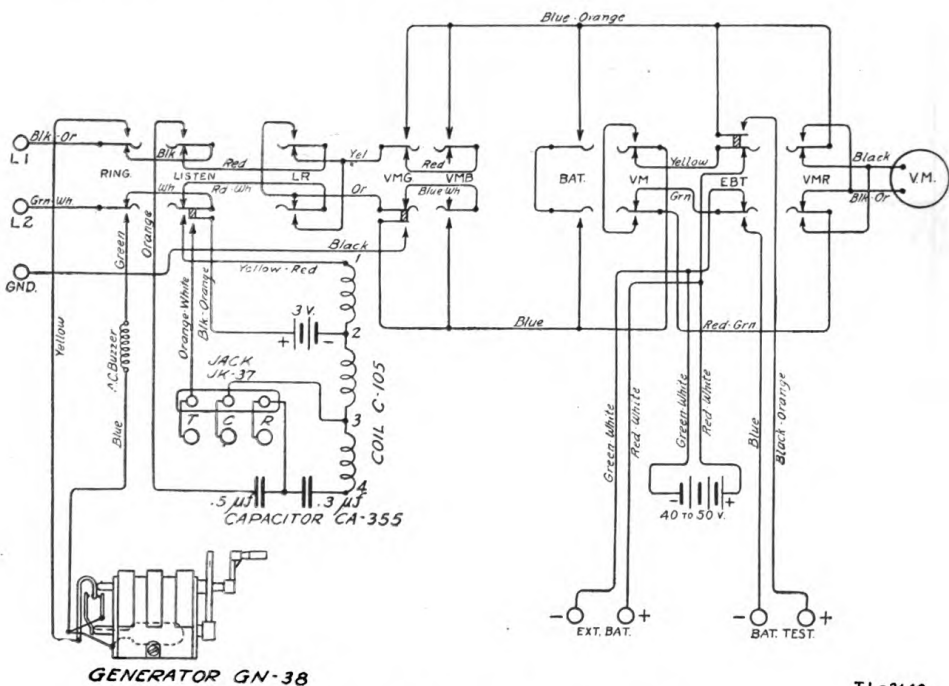


FIGURE 6.—Circuit diagram, test set EE-65-A.

h. Figure 13 shows the circuit for measuring the voltage of any source of d-c potential that may be connected across the BAT TEST posts. Key No. 5 when operated downward connects the voltmeter across the BAT TEST posts and, at the same time, disconnects it from the test terminals and the testing battery. Care should be taken to insure that the voltmeter is used to measure only such potentials as lie within its range. Also see that the positive terminal of the source of d-c potential is connected to the positive terminal of the set. Excessive voltage may injure the voltmeter, and a reversed battery may bend the needle thus causing it to become inaccurate.

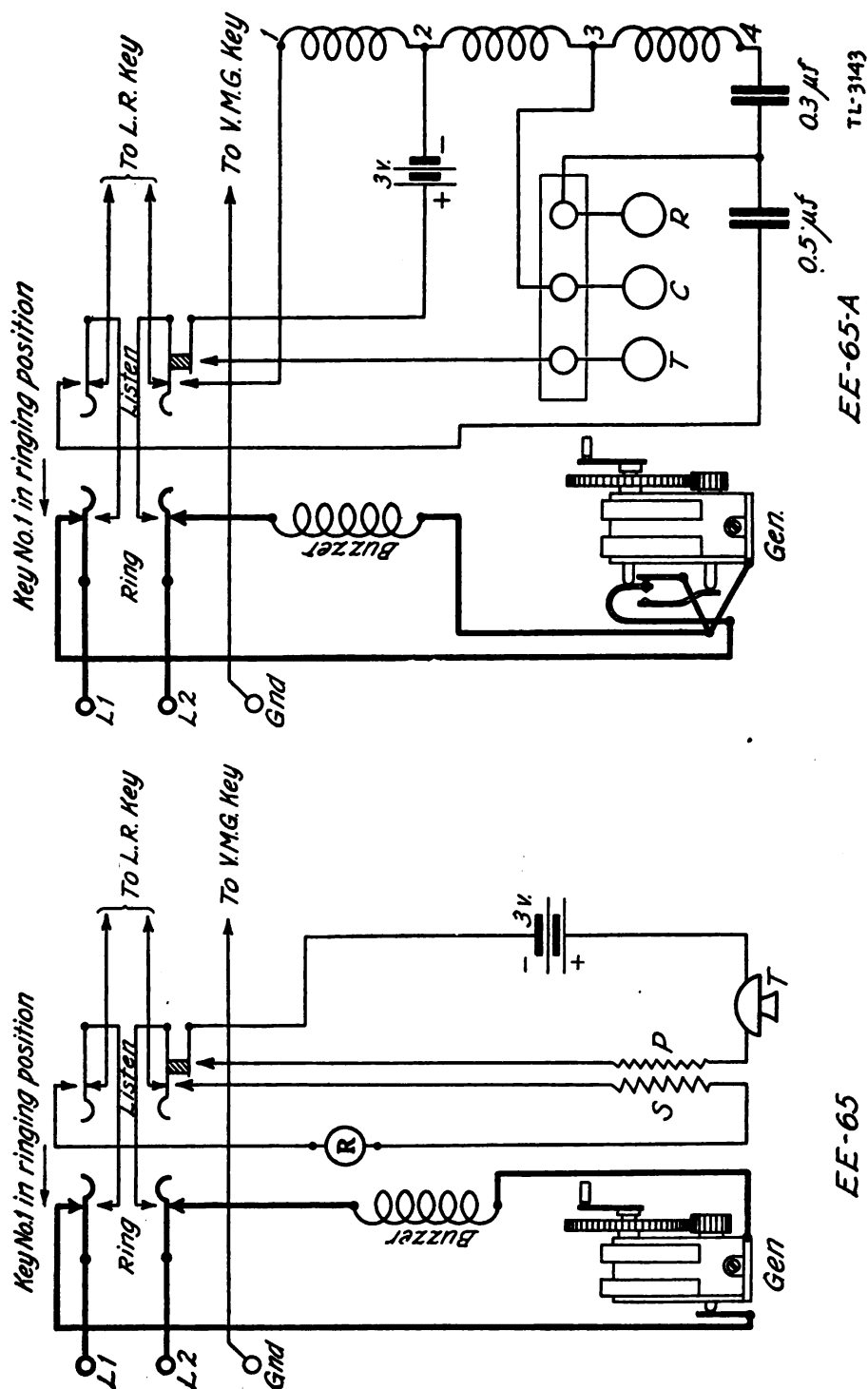


FIGURE 7.—Ringing circuits.

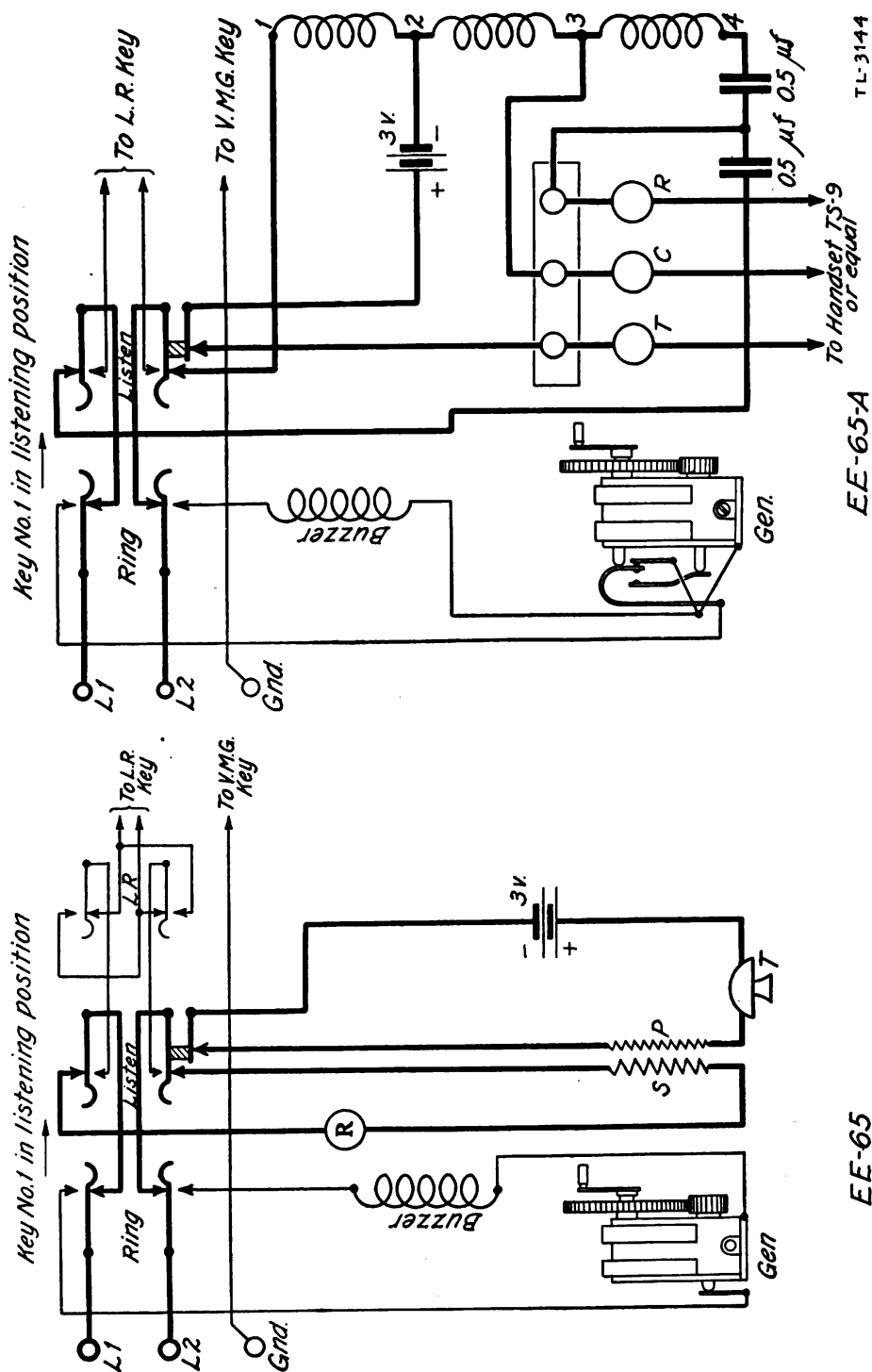


FIGURE 8.—Talking and listening circuits.

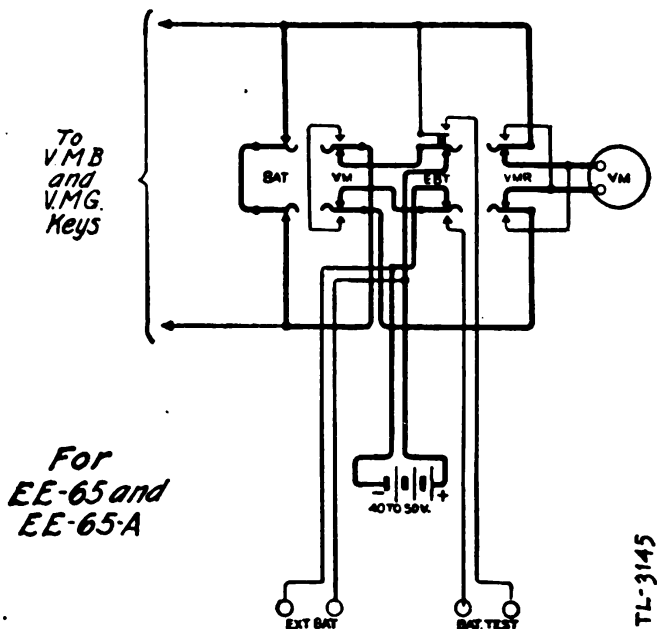


FIGURE 9.—Circuit for measuring voltage of testing battery.

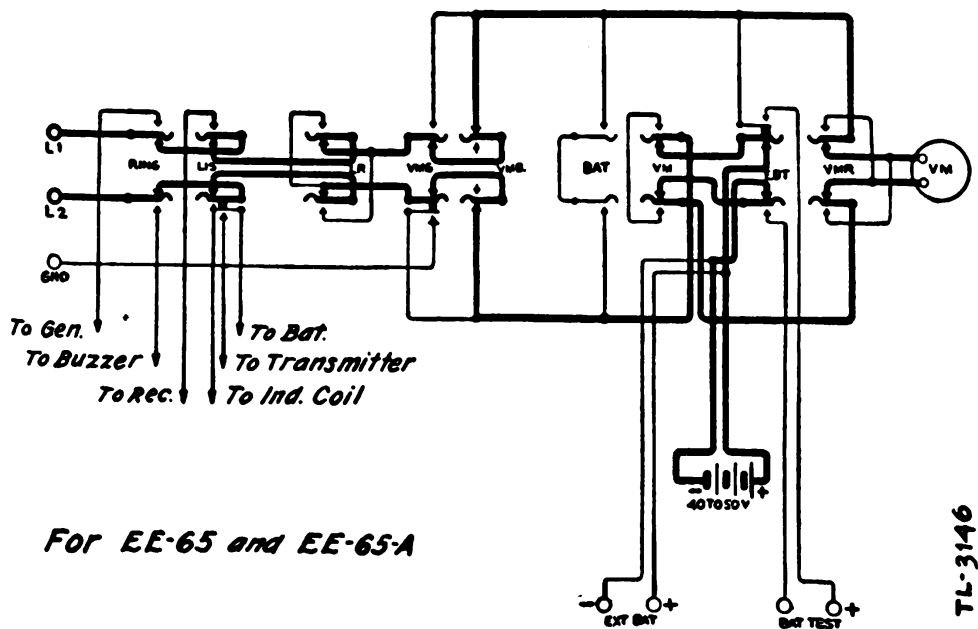


FIGURE 10.—Continuity test and external resistance test circuit.

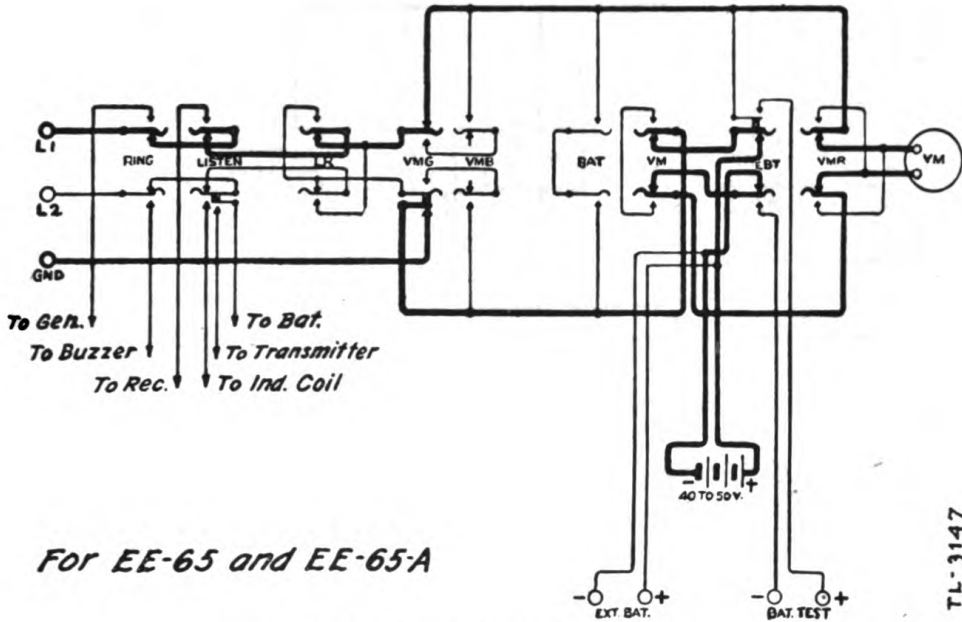


FIGURE 11.—Circuit for testing for grounds.

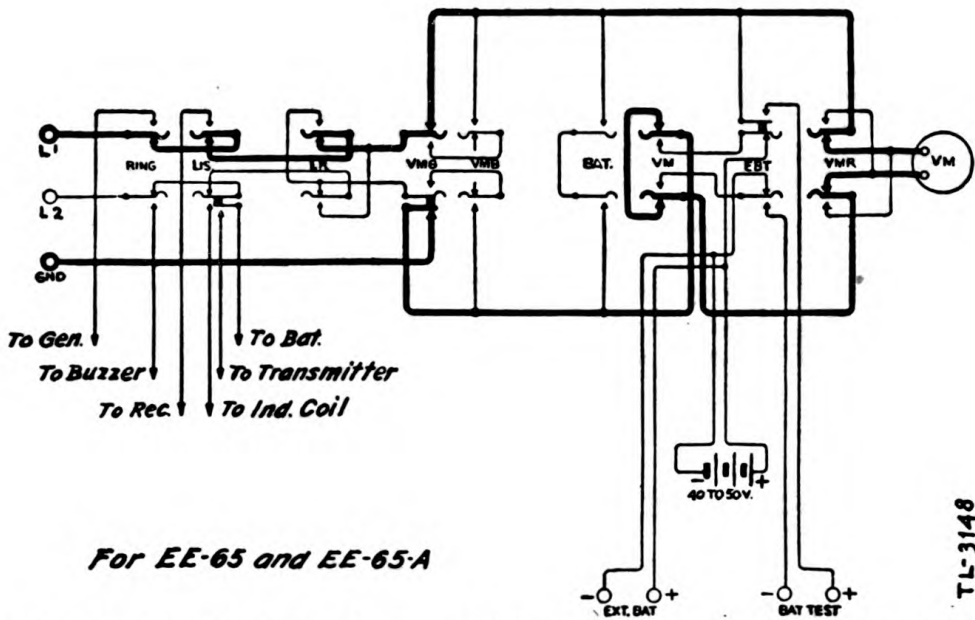


FIGURE 12.—Circuit for testing for crosses between two lines, one of which carries current.

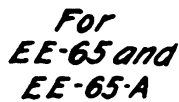


FIGURE 13.—Circuit for determining value of external voltage.

MAINTENANCE

Procedure

c. Operate key No. 4 down and read the battery voltage. The voltage should be approximately 44 volts when the battery is new. When the voltage falls to 38, new batteries should be installed. If

new batteries BA-2 are not available, a temporary external battery can be substituted by connecting 30 dry cells in series to the posts marked EX BAT. Before connecting the external battery be sure that the old battery in the test set has been disconnected.

d. Operate Key No. 1 up and short-circuit the test leads L-1 and L-2. Place the receiver to the ear, press the transmitter button, and blow lightly into the transmitter. If sound is clearly reproduced the transmitter battery is in satisfactory condition. The transmitter battery in test set EE-65 is a BA-1, and in test set EE-65-A comprises two batteries BA-30.

e. Connect three or four dry cells in series to the L-1 and L-2 leads. Operate key No. 3 down and key No. 4 up and if the voltmeter shows a reading, this part of the circuit is functioning properly.

f. Connect GND to the L-1 test lead. Operate key No. 3 up. If this circuit is working properly the voltmeter needle should read the full voltage of the test battery. This completes the check tests on the set and only occasional tests of this nature should be necessary. The most probable troubles that will develop in the set are battery and cord troubles. Care should be used to see that no strain is placed on the cord terminals.

SECTION V

TABLES

	Paragraph
Wire and cable resistance and weight.....	24
Insulation resistance.....	25

24. Wire and cable resistance and weight.—Resistances and weights of wires and cables most commonly used by the Signal Corps for communication purposes are given in the following table. (The resistance given is approximate at a temperature of 68° F. (20° C.) and will be greater for a higher temperature and less for a lower temperature.)

	Weight per mile	Resistance per mile of single con- ductor
	<i>Pounds</i>	<i>Ohms</i>
Hard-drawn bare copper wire:		
No. 8 A. W. G.-----	264	3. 4
No. 9 A. W. G.-----	209	4. 3
No. 10 A. W. G. (or No. 12 N. B. S.) (wire W-74)---	166	5. 4
No. 12 A. W. G.-----	104	8. 5
No. 14 N. B. S.-----	104	8. 5
Galvanized iron wire:		
No. 9 B. W. G. (wire W-75)-----	312	15
No. 10 B. W. G.-----	258	19
No. 12 B. W. G.-----	179	29
No. 14 B. W. G. (wire W-76)-----	99	49
Bronze, No. 17 A. W. G., single, solid (wire W-73)-----	33	95
Outside distributing, twisted pair, copper clad, solid, No. 17 A. W. G. (wire W-38)-----	240	96
Outside twisted pair, solid, No. 14 A. W. G. (wire W-50)---	375	14
Parallel drop wire, copper clad steel or bronze tinned, solid, No. 17 A. W. G. (wire W-108)-----	216	94
Field, 11-strand (10 steel, 1 copper):		
Single (wire W-39)-----	90	52
Twisted pair (wire W-40)-----	184	53
Field, 7-strand:		
Twisted pair (5 steel, 2 copper) (wire W-110)-----	132	130
Twisted pair (4 steel, 3 copper) (wire W-110-B)---	132	95
Outpost wire, 7-strand (3 steel, 4 bronze):		
Single (wire W-43)-----	63	161
Twisted pair (wire W-44)-----	130	164
Buzzer (2 steel, 1 copper) (wire W-45)-----	26	340
Assault wire, 7-strand (6 steel, 1 copper), twisted pair (wire W-130)-----		
	32	317
Cable, paper-insulated, lead-covered:		
No. 19 A. W. G., 10 pair (commercial article)-----	2, 957	43
No. 22 A. W. G., 10 pair (commercial article)-----	2, 112	86
Cable, rubber-insulated, rubber-covered:		
No. 19 A. W. G., 5 pair (cable WC-534)-----	680	43
No. 19 A. W. G., 10 pair (cable WC-535)-----	400	43

25. Insulation resistance.—Value of X (resistance) with corresponding values of V' (voltmeter reading) with test battery of 40 volts (see par. 19).

V' -volts	EE-65; volt- meter resist- ance, 3,000 ohms X -ohms	EE-65-A; voltmeter resistance, 50,000 ohms X -ohms	V' -volts	EE-65; volt- meter resist- ance, 3,000 ohms X -ohms	EE-65-A; voltmeter resistance, 50,000 ohms X -ohms
1-----	117, 000	1, 950, 000	13-----	6, 230	104, 000
2-----	57, 000	950, 000	14-----	5, 570	93, 000
3-----	37, 000	617, 000	15-----	5, 000	83, 300
4-----	27, 000	450, 000	16-----	4, 500	75, 000
5-----	21, 000	350, 000	17-----	4, 050	67, 600
6-----	17, 000	283, 000	18-----	3, 660	61, 100
7-----	14, 140	236, 000	19-----	3, 320	55, 260
8-----	12, 000	200, 000	20-----	3, 000	50, 000
9-----	10, 330	172, 000	25-----	1, 500	30, 000
10-----	9, 000	150, 000	30-----	1, 000	16, 700
11-----	7, 900	132, 000	35-----	428	7, 140
12-----	7, 000	117, 000	40-----	0	0

[A. G. 062.11 (6-12-41).]

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(For explanation of symbols see FM 21-6.)

